SCIENCE IN YOUR SHOPPING CART

Some of the many ways, both familiar and surprising, that agricultural research touches and improves daily life in the United States

U.S. DEPARTMENT OF AGRICULTURE • AGRICULTURAL RESEARCH SERVICE

Program Aid 1558

As the main in-house research arm of the U.S. Department of Agriculture and one of the four agencies that make up the Research, Education, and Economics mission area, the Agricultural Research Service is committed to:

Providing access to agricultural information and developing new knowledge and technology needed to solve technical agricultural problems of broad scope and high national priority to ensure adequate availability of high-quality, safe food and other agricultural products to meet the nutritional needs of the American consumer, to sustain a viable and competitive food and agricultural economy, and to maintain a quality environment and natural resource base.

March 1996; reprinted, with typographical corrections, November 1996

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We pay less for food than citizens of other nations; the United States enjoys the cheapest food in the world.

But as you walk through the grocery store, do you ever wonder where such an abundance and variety of food and products came from?

Each year, dozens of improved products and new varieties of fruits, nuts, and vegetables emerge from the laboratories and greenhouses of the Agricultural Research Service.

Next time you find yourself behind a shopping cart, take a look. You'll find that there's plenty of scientific know-how on your supermarket shelves!

THE WELL-POLISHED APPLE

Apples are an all-American success story—each of us eats more than 19 pounds of them annually. Thanks to fruit-breeding research, we're able to enjoy more productive, healthy, and flavorful **new varieties** every year. And we're collecting and preserving the world's bounty of apple genestock, so that the apples of tomorrow may be even sweeter, crunchier, and better than ever.

Think about the quality of the apples you buy at the supermarket: They may have been stored for as long as 9 months, but you can bet they'll remain crisp, thanks to **controlled-atmosphere-storage** methods devised by ARS. Never before have growers had a better chance against pests and diseases in the apple orchard, thanks to new, nonchemical biocontrols. ARS scientists have toiled to harness naturally occurring yeasts and bacteria and turn them against apples' enemies.

We've even worked on **bashless bagging**—packaging systems that are used by wholesalers to bring you apples without bruises.

And thanks to ARS quality-control research, American apples have become internationally popular. Now they can even be found in the most select markets of Japan.

CARROTS, ONIONS, GARLIC, CUKES

Thanks to research, carrots, onions, garlic, and cucumbers taste better and contain more nutrients. And better crop yields and disease resistance make more of these favorite foods available.

Remember the old joke about carrots' vitamin A being good for your eyes? (You never saw a rabbit wearing glasses, did you?) Well, ARS research has brought us a carrot that's healthier than ever. Today's carrots pack twice **the beta carotene** as their predecessors did 30 years ago, and researchers expect to triple this important source of vitamin A by the year 2000.

Thanks to our pioneering work in lightly processing foods, the freshly peeled carrots sold in the produce section are free of the white film that sometimes masks their bright orange color. Processors simply dip the peeled, ready-to-eat vegetables in a heated bath of water and citric acid for 30 seconds and then quickly dunk them into cold water. The technique is simple, fast, inexpensive, and additive-free. It won't affect taste either. The heated citric acid, which is a natural product of citrus fruit, simply stops unwanted enzymes from forming.

We've **altered onions** too. Sweet Sandwich is now marketed as a sweet onion that offers an alternative to Vidalia onions. It can be stored 9 months without using any chemicals to inhibit sprouting.

And added to our plant-breeding work with cucumbers, we've worked with picklemakers to prevent a common problem known as "pillowing" that discolors finished pickles.

LOTS AND LOTS OF LETTUCE

Nearly every head of iceberg lettuce you'll find in a supermarket owes its parentage to the work of ARS plant breeders. Salinas iceberg lettuce and its progeny are the **most widely planted iceberg lettuces** in the Salinas Valley of California, the world's foremost lettuce-growing region. Farmers in other parts of the United States and foreign countries from Sweden to Australia also raise these lettuces.

It's amazing what lettuce breeders can accomplish! Can't eat an entire head of lettuce by yourself? Never fear—an inventive ARS plant breeder devised an **iceberg mini-lettuce** that makes just enough salad for one person to eat at one sitting.

How do they do it? Lettuce breeders rely on the ARS gene bank, which houses seeds of more than **2,000 lettuce types**. The genes that are banked there today should result in lots more lettuce-magic soon. Look for traits like the warm gold of a Hungarian lettuce or the **intense crimson** of a Spanish variety to be introduced into the familiar lettuces that are grown in the United States today.

A PERFECT PEACH, A PRETTY PEAR

We think of peaches as coming from Georgia. Well, they do, but not exclusively. ARS researchers at Kearneysville, West Virginia, have released varieties that reliably produce sunny, juicy peaches in **northerly climes**. Look for them to do well despite the harsh winters of, say, central Pennsylvania.

A laboratory technique called embryo culture has proven especially helpful in creating new peach varieties. When nurtured in petri dishes, tiny embryos that could not survive in nature are cultivated into plantlets. Tended carefully in the greenhouse, the plantlets can eventually be planted outdoors in the research orchard.

With regard to the many insect and disease problems that afflict orchard crops, ARS scientists look for nonchemical, **environmentally friendly solutions** whenever possible. For example, they've developed breeding lines that are resistant to Peach Tree Short Life and a bacterial biocontrol that prevents brown rot on fruit.

Pear research has also borne fruit. Thanks to years of pest control studies, the fire blight and pear psylla problems that long ago wiped out the U.S. East Coast pear industry have yielded to a variety of new controls. We've even come up with computer programs to help growers predict when fire blight will strike, so they can be ready for it. The program, which has been tested in over 20 locations throughout the United States and Canada, has resulted in better fire blight control and has reduced the number of sprayings that orchards receive.

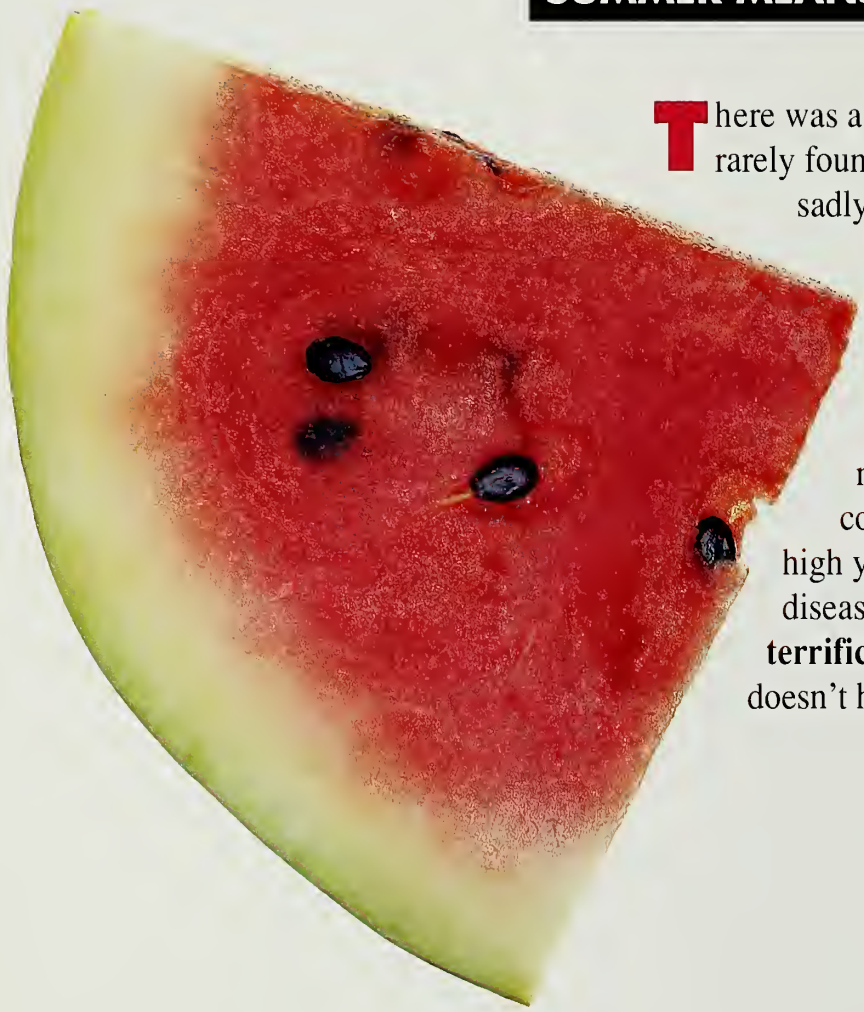
DOWN-HOME PECANS

It's not a nutty idea—pecans are good for you! They've not only got protein, potassium, phosphorus, and magnesium, but even calcium! Okay, so they contain fat too, but 95 percent of it is unsaturated.

Unfortunately for pecan trees, worrisome diseases keep popping up. In the past couple of years, scientists have uncovered two new ones. They're working alongside growers to come up with management strategies.

One solution is to breed disease resistance into the crop. ARS conducts **the world's only pecan-breeding program**, serving growers in the United States, Mexico, and other pecan-growing countries. Out of this program came **Pawnee**. Released in 1984, this variety is blessedly insect- and disease-resistant and produces notably large nuts of high quality as well.

SUMMER MEANS WATERMELON



There was a time, a half century ago, when a good watermelon was rarely found in a grocery. Melon lovers had to grow their own, which, sadly, wouldn't keep for long.

Then, in the 1940's, along came a USDA plant breeder who set out to bring us a better watermelon. The result was **"that gray melon from Charleston,"** formally called the Charleston Gray. Its oblong shape and hard rind made it **easy to stack and ship**. Its adaptability meant it could be grown over a wide geographical area. It produced high yields and was resistant to the most serious watermelon diseases, anthracnose and fusarium wilt. Best of all, it **tasted terrific**! Today, there is hardly a watermelon variety grown that doesn't have a little Charleston Gray in its lineage.

IT'S THE BERRIES!

A bowl of berries is a treat for the eye as well as a delight for the palate. But these tasty little morsels happen to be quite tricky to grow, harvest, and handle. These crops tend to have brief growing seasons and are vulnerable to insects, disease, and even birds, so ARS scientists have given them lots of attention.

Take strawberries. In the 1950's, ARS actually saved the strawberry industry in the Great Lakes region when we released the first varieties that could survive red stele, a root-rotting fungus. We're also old hands at strawberry breeding. ARS came up with such June-bearing favorites as Earliglow, a sweet and juicy berry with a wonderful flavor. We've also bred berries that bear fruit from spring until well into the fall like Tribute and Tristar, which have brought new market opportunities to Northeast strawberry growers.

Fifteen years ago, blueberries were practically nonexistent in the Gulf States. But our early-ripening varieties have extended highbush blueberry culture to the Deep South. Today, over 10,000 acres are grown in Dixie, with more than 4,000 acres thriving throughout Texas, Louisiana, and Alabama.

In the Pacific Northwest, where most of our red raspberries are grown, Willamette, a 1943 release, still accounts for 40 percent of the red raspberry acreage.

And, when USDA blackberry breeders introduced the first truly genetic thornless blackberries, Thornfree and Smoothstem, they caused a small roadside revolution. The new varieties were just what some growers needed to establish pick-your-own operations.

PLEASE PASS THE PEANUTS

When you add it all up, peanuts aren't just peanuts—they're quite an important crop. The United States produces between 3 and 4 billion pounds of peanuts annually, and about 40 percent of these go into processed foods, from salted peanuts, candy, crackers, and cookies to peanut butter. They're a major source of vegetable oil too.

Peanuts have been the object of scientific study since George Washington Carver's day. ARS scientists have worked to improve **peanut flavor and quality** both by breeding better peanuts and by finding better ways to process them. Success came with the discovery of ways to extend the shelf life of peanut products, since unstable fatty acids in peanuts can cause unpleasant flavor changes. We've also found ways to remove part of the oil from the peanut without serious loss of flavor. Partially defatted peanuts are now sold by several companies, and the market is growing.

With the help of precision lab instruments and the sensitive noses of volunteers, ARS chemists have pinpointed chemicals that are crucial to that **unmistakable peanutty flavor**. This work reveals that roasted peanuts probably owe their rich, nutty aroma to a blend of about a dozen natural compounds. The findings could be used to enrich the flavor of roasted peanuts by adding back compounds that are sometimes lost in processing.

A HOT COMBO—TORTILLAS AND CHILI PEPPERS

The hearty flavor of corn flour products like tortillas and taco shells is largely the work of a natural compound identified by ARS scientists. They have pinpointed 2-amino-acetophenone as key to flavor and aroma of **yellow corn tortilla flour**. Twenty taste panelists were enlisted to nose out the correct compound from a field of 30. The information can help foodmakers check the quality of their products.

Ever consider growing your own fiery cayenne pepper? We've bred a new hot pepper that's **20 times hotter** than the typical cayenne, and it's ideal for growing in the home garden. One plant will produce at least 134 pepper pods, and it grows just about anywhere in the United States.

ABOUT THAT LOAF OF BREAD...

Leavened bread has been around a long while—since the days of ancient Egypt, Babylon, and Greece, in fact. Then, as now, it was made from wheat, or from a mixture of wheat and rye. The elastic gluten in wheat is essential for bread to rise.

But a lot has changed—today's bread is mass-produced. Brews of yeast, made in huge vats, are mixed continuously with flour, water, and other ingredients at one end of a machine. At the other end, dough is squished out of a tube, shaped, and cut automatically into loaves. The loaves drop into pans, rise, and are baked at the rate of thousands an hour.

Our bread also contains more ingredients and additives, which causes special problems for the baker, miller, and farmer. Even the same classes of wheat can vary significantly in baking qualities. And when these differences are great enough, they can cause a lot of trouble in a bread factory!

For 50 years, ARS laboratories have worked with all segments of the industry to help provide consumers with uniform, flavorful, nutritious bread and other wheat products. They identified and isolated wheat proteins not previously known to exist. They showed that these proteins—gliadin and glutenin—contain a specific chemical structure that affects mixing properties of flours in forming doughs They discovered the role of fatlike constituents in flour in controlling volume of bread and size of cookies. They found that certain water-soluble proteins called albumins are as essential as gluten in producing a good loaf of bread.

And over the years, ARS technologists baked thousands of loaves of bread to test different flours and to determine the effects of new additives.

Busy though scientists have been, research is accelerating. Today, with a sample no larger than half a kernel, a chemist can analyze a type of gluten protein and determine its baking properties. This can help wheat breeders get an early indication of the kind of flour their most promising plants will produce. "It provides us with an incredible amount of information," says one researcher. "And it gives it to us in a day instead of months or years."

Other scientists work with glutenin, the other important protein in wheat gluten. Not all glutenins, it turns out, are created equal. A team of chemists is exploring the structure of glutenins of assorted molecular weights, shapes, and sizes. The research could help in the genetic engineering of glutenins that can outperform those of today.

AMBER WAVES OF EVER-IMPROVING GRAIN

Across the country, ARS scientists who work with wheat aim to make U.S.-grown grain better all the time. It's not an easy job. Techniques for successfully slipping new genes into crops like tomatoes or petunias typically don't work on wheat.

But years' worth of efforts have brought about many hard-won victories. A yardstick for our wheat-breeding success is the popularity of the new varieties we've come up with.

One variety alone accounts for most of the soft red winter wheat that's grown in the Eastern United States. Why? Because it stands up to wheat's most destructive disease, leaf rust.

Other varieties have amazed even dubious wheat farmers by resisting the Hessian fly and cereal leaf beetle, two costly insect pests.

And we expect more progress in the future. The wheat plants of tomorrow may be genetically tailored quickly and easily to yield more nutritious flour or more effectively fend off insects and disease, now that ARS scientists have found shortcuts for shuttling new genes into wheat embryos.

Growers can increase their expertise, thanks to an ARS-developed computer program called MoreCrop. At the touch of a few buttons, a grower can get customized advice on diseases to watch out for and treatments that are appropriate to specific conditions.

THE GREAT SAN FRANCISCO SOURDOUGH CAPER

Bakers in the Bay Area insisted their sourdough bread couldn't be duplicated farther than 50 miles from the center of San Francisco. Didn't know why, either. It just couldn't.

Enter ARS researchers, who knew there was a scientific answer to the mystery of sourdough bread. They started looking for clues.

One puzzling thing about the bread was its high acetic acid content, which contributed to its tangy taste. Yeasts generally can't tolerate acetic acid.

Obtaining samples of starter doughs from five local bakeries, a scientist found in all five a bacterium never before discovered. Naming it *Lactobacillus sanfrancisco*, he spent several months and tried 30 different substances before finding a medium in which it would grow.

The other thing he found was an unusually acid-tolerant yeast, *Saccharomyces exiquus*. It worked with the bacterium in a symbiotic relationship to produce the bread's unusual flavor, crust, and texture. Comments the scientist: "It was a happy marriage between two noncompetitive bugs."

So now San Francisco-style sourdough bread can be baked anywhere in the world. Which turned out not to be bad news for the City by the Bay. Pure cultures of *L. sanfrancisco* are now grown commercially and are commonly used by San Francisco bakers to control the quality of their product.

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FROZEN FOOD THAT'S FREEZER FRIENDLY

In the early years of frozen food, a whole host of complaints poured in about things like cardboard texture, funny color, and no taste. Some people also worried about lost nutrients and bacterial contamination during processing and storage.

Then ARS scientists began the Time-Temperature Tolerance Project. Building their own freezing facilities inside their lab, scientists experimented with every step in the process, from selection of the variety grown to harvesting, handling, blanching, freezing, packaging, storing, and transporting products to market.

What these scientists learned helped immeasurably to ensure the survival and growth of the U.S. frozen food industry.

In time, they devised nine principles for freezing vegetables. Producers still follow these cardinal rules today.

THE CONVENIENCE OF FROZEN DINNERS

Not every fruit or vegetable responds to freezing well—strawberries and green beans, for example, do not. Juices leak from thawed strawberry cells and green beans lose texture. ARS researchers found that rapid freezing of berries and beans with liquid nitrogen resulted in much more satisfactory products.

Many processed foods also resist freezing. Back in the '50's, the first TV dinners were praised for their quick preparation time but often went uneaten because of their curdled gravies and sauces. ARS to the rescue! We substituted a flour made from waxy, or glutinous, rice for wheat flour to thicken the gravies. Sure enough, gravies stayed smooth after freezing. The same trick worked on frozen puddings, replacing the traditional cornstarch thickener.

You probably haven't heard of dehydrofreezing, a process in which fruits and vegetables are partially dehydrated before freezing to cut their weight in half. Its chief commercial use today is in freezing pieces of potatoes and apples for institutional use. But researchers are willing to bet its use will soon be expanded; keep an eye out in your supermarket's frozen food case!

THE NINE PRINCIPLES FOR FREEZING VEGETABLES

1. The product must be freezable. Peas freeze; cucumbers do not.
2. The variety must be suitable. Garden peas, for example, freeze better than peas grown for canning.
3. The raw product must be first-class. Freezing preserves defects as well as superior quality.
4. Handling between field and plant must be as prompt as possible.
5. Natural enzymes must be inactivated by blanching.
6. Freezing must be fast enough to ensure quality, yet economical enough to be competitive.
7. The plant must be kept sanitary and the line clean to prevent contamination by molds, yeasts, and bacteria.
8. Packaging must ensure that no moisture is lost during a year's storage.
9. Storage temperatures must be uniform, and never, never exceed 0° F.

MORE AND BETTER CITRUS

More than 70 percent of all citrus fruits grown in the United States are varieties developed by the ARS citrus breeding program.

In Florida, we've come up with citrus varieties that are higher yielding with increased disease resistance, better color, and longer shelf life. A major success story is Ambersweet, a cold-hardy citrus that's been approved for use in orange juice products. Because it withstands Florida's occasional cold snaps that can ruin most citrus, Ambersweet is being widely planted in the Sunshine State. It took 20 years of patient breeding to develop it, but the payoff is huge.

If there's usually a grapefruit in your shopping cart, you may already have met up with a favorite ARS-created variety. It's a red-fleshed, thin-skinned, seedless grapefruit that was developed and released in 1987. Since then, over 4 million Flame nursery trees have been propagated in Florida. No other grapefruit variety has ever been so widely accepted and planted.

Orange sections can now be prepeeled by a patented ARS process that uses commercially available food-grade enzymes. The process also removes the bitter white portion of grapefruit peel, eliminating hand-peeling and allowing more precise portion control. And the prepeeled fruit is ideal for school lunch programs and restaurants.

Keeping oranges fresh is another citrus-oriented task we've taken on. Oranges that have been covered with our specially designed coating will stay fresh for up to 3 weeks at room temperature. In that time, fruit treated with the usual grocer's coatings will look shrunken and discolored.

TURNING ON THE JUICE

Fifty years ago, frozen orange juice was just a flavorless commercial flop. The only orange juice you could get back then was either squeezed from fresh oranges, mixed from a relatively tasteless concentrate, or poured from a can—and it tasted like can!

All this at a time when lots of good Florida oranges were going to waste.

Then, in 1946, Louis G. MacDowell, director of research for the Florida Citrus Commission, had an idea. He suggested that adding a little single-strength fresh juice, or "cut-back," to slightly overconcentrated orange juice might restore the flavor and aroma lost during vacuum evaporation.

He took the idea to USDA researchers, the folks with the equipment and expertise to help develop the idea. Not only did it work but the vastly improved concentrate could be easily frozen. And so began the success story that's now such a familiar sight on the breakfast table—frozen concentrated orange juice.

AH! SWEET MYSTERIES OF CHEESE

A long-standing **mystery about the molecular structure** of casein—the main protein group in milk—has been solved. The new information is helping cheese producers develop more effective and reliable processing methods. ARS scientists learned that at the molecular level, casein is truly unique. Its structure is very loose, and it contains at least 10 times as much water as any other protein. This discovery may enable cheesemakers to automate the initial and often costliest stage of cheese production—the step when enzymes are added to milk.

We've also come up with a chemical test that helps cheesemakers make sure their cheeses are properly aged and ready to sell. It's a procedure that commercial dairies can automate to check such products as Cheddar, feta, and Monterey Jack.

Imagine an all-natural new mozzarella cheese that contains less than 10 percent fat—that's less than half the 23 percent in full-fat mozzarella! Our innovative new cheese technology gives superior melting quality and texture to commercial reduced-fat mozzarella cheeses. And, our team of teenage taste-testers reports, it's great on pizza!

WANT TO TRY FROZEN MILK?

When you're low on milk, wouldn't it be great to simply reach into your freezer, grab some concentrate, and whip up an extra couple of quarts?

The idea's not new. Frozen milk has been tried before, but always with unsatisfactory results. The glitch is in milk's butterfat—once frozen, it doesn't reconstitute well.

ARS scientists sidestepped the butterfat problem by combining nonfat dry milk with water, then blending in cholesterol-free vegetable oil. No butterfat, no need to homogenize! Reconstituting is quick and easy. A single pint of concentrate brings you 2 quarts of milk. When reconstituted, it's got the texture of whole milk but the cholesterol content of skim milk.

We've passed the technology on to private industry for marketing consideration.

LACTOSE-FREE DAIRY PRODUCTS

Are you among the many American adults who have trouble digesting lactose? Then you may already know about the lactose-free dairy products that we've developed by altering a bacterium used to make cheese and yogurt. It produces an enzyme that in turn breaks down the milk's lactose, sparing you an upset stomach.

MAKING MORE MILK

Because much of the cost of a cow is the feed and labor needed to maintain her, fewer but higher yielding cows mean lower priced milk. Dairy herd improvement ultimately benefits consumers.

That's why it's just as important to keep complete and accurate records as it is to keep the cows contented. The National Cooperative Dairy Herd Improvement Program has been tracking Bossy's milk yields since 1905.

Over the years, this program has made enormous contributions to dairy cattle breeding. ARS scientists receive the lactation records of all herds enrolled in the program and use the figures to rank the bulls that sire the nation's dairy cows and to rank the cows themselves.

The results of years and years of scientific dairying? Milk production has been trending upward for more than 25 years in the United States—from about 117,000 million pounds in 1970 to more than 150,000 million pounds in 1994—even though the number of milk cows has been reduced.

THE GRAPES OF CRAFT

Sweet, juicy grapes, picked at the peak of ripeness, are one of nature's best-tasting treats. In vineyards, greenhouses, and laboratories, ARS scientists seek to bring even better grapes to your shopping cart tomorrow.

The ARS laboratory that developed America's most popular red seedless grape, Flame Seedless, has also offered nurseries and breeders a delicious new black seedless grape. Called Black Emerald, the newcomer is a sweet grape with berries about the size of a dime. The flesh is translucent, firm, and almost crisp.

Also watch the supermarket for Autumn Seedless, a light-green grape that became available to nurseries and growers in 1984. It is ready for harvest about 2 weeks before Thompson Seedless.

Of course, all grapes need to be properly handled. ARS studies of packaging have shown that boxes with a shrink-wrap covering offer the best insurance against loss to disease, weight loss, and shatter (grapes' tendency to drop off the stem). Plastic dome-lid boxes with vent holes are also protective. Net bags, for years considered the preferred packaging, proved the least safeguard of all.

From the East Coast to the vineyards of the Far West, grapes are a growing success story. And, since two ARS gene banks, in Geneva, New York, and Davis, California, are living treasure troves of grape varieties, we expect more juicy developments ahead.

POTATO A-PEEL

Yes, Americans do love their spuds! We each eat about 125 pounds of them a year, about half from fresh potatoes and half in processed foods. Research has brought forth a slew of new, improved potato varieties for both uses.

Take, for example, Atlantic—it makes potato chips with lower fat content than any other variety, thanks to its low ratio of water-to-solid-tissue. Atlantic is now the Nation's number one chipping potato.

Are you one of the millions of Americans who never peels potatoes? Then perhaps you rely on our instant potato flakes. We invented the process in 1954 to help use up surplus potatoes. Our instant flakes were an instant hit and a big improvement over earlier powdered potatoes. Today, about 400 million pounds of potato flakes are produced each year in the United States.

Ever have a bag of potatoes go bad? Then you've probably met *Phytophthora infestans,* a fungus that can suddenly turn potatoes into a slimy, smelly mess. Over the years, this fungus, which affects potatoes in storage and in the field alike, has been controlled by chemicals. Lately, though, the microorganism has been showing a worrisome resistance. ARS scientists are developing new solutions to combat this old problem.

RICE IS NICE

Cultivated rice, a billion-dollar annual crop, is grown in only six States: Arkansas, California, Louisiana, Texas, Mississippi, and Missouri. Long-grain, an American favorite, is raised chiefly in the South, medium and short-grain rice mainly in California. And everywhere that rice is grown, ARS research stands behind the crop.

Much of this work involves breeding better rice. In 1993, a single ARS-developed semidwarf rice variety, Lemont, covered 600,000 acres. That same year, its cousin, Gulfmont, contributed another 147,000 acres. Together they accounted for nearly 30 percent of the rice in four States. Semidwarf varieties are notable for their short, stout stems that don't fall over in a strong wind or rain; nor will the grain-laden head snap off before it can be harvested.

For the expanding Asian market, both here and abroad, we've worked on a long-grain rice that smells of jasmine as it cooks. Jasmine 85 was originally bred in the Philippines, but ARS scientists developed the methods for growing it in Texas.

Science has doubled the shelf-life of brown rice—from 6 months to at least 1 year. And researchers have found a way to make yeast-leavened bread from rice flour, a boon for people who are allergic to wheat protein. Taste panels report it is almost indistinguishable from bread containing wheat flour.

To bring you a better product, we've made changes in rice milling that resulted in less breakage of grains during processing.

POULTRY

Americans today are eating about 14 pounds of turkey apiece each year, more than double the rate 20 years ago. And virtually all of those commercial turkeys owe part of their genetics to the Beltsville Small White, a small turkey bred to have lots of white meat.

Not only are turkeys themselves improved, but rearing turkeys has become a lot easier for producers, thanks to scientific innovation. The Beltsville Poultry Semen Extender enables poultry producers to set up "turkey stud farms" with only the best males, thus making the most efficient use of artificial insemination.

Keeping dangerous microorganisms out of poultry is a long-standing ARS research goal. In the course of this research, we made history with the first Federal cooperative research and development agreement with industry. Teaming up with Embrex, Inc., of North Carolina, we learned how to vaccinate hatching eggs against coccidiosis, a chicken disease that costs producers about $300 million annually. Since then, we've developed a similar method for injecting "good" bacteria into incubating eggs to combat *Salmonella,* thus reducing costs to producers and improving quality and safety for consumers.

BETTER BEEF

You might have a hard time finding top-quality beef at the supermarket if it weren't for all the behind-the-scenes attention that beef cattle receive. An unprotected herd can be hit hard by unseen hordes of bacteria and viruses. Brucellosis, shipping fever, and bovine tuberculosis are just a few of the fierce diseases that consumers won't have to worry about as long as researchers do. The ARS animal research has resulted in many, many new animal medicines and programs to prevent disease transmission, and the battle against disease continues to be high-priority work.

The health of beef cattle is important, and so is the condition of the range environment where cattle graze. Rangeland management schemes have been redesigned to match cattle populations to available forage, and grasses have been bred to offer top nutrient value while growing harmoniously alongside wild species.

Today's consumers ask for lean beef, so ARS scientists across the Nation are looking for ways to meet those requests. Scientists are identifying marker genes associated with fat and other characteristics. These markers could help growers identify precisely which animals they want in the herd to produce lean beef for consumers. And while in the past, producers tried to feed their cattle as much as possible to fatten the animals, science has shown them ways to get growth without as much fat.

While it's not always possible to predict the tenderness of a cut of meat, meat researchers have found that meat treated with calcium chloride, an approved food additive, can be made tender in just 1 day.

PROCESSED MEATS

Whether your sandwich contains bologna or corned beef, you want it to be at its most flavorful. ARS has looked at the source of flavor differences in beef, pork, lamb, and veal to find out what happens when it's aged in storage. They found, for example, that Lebanon bologna—a traditional Pennsylvania Dutch product—gets its distinctive flavor not from the use of old barrels, as thought. It comes from the amount of salt used in aging the meat.

An ARS scientist changed the way that fermented meats like pepperoni and Genoa salami are made. He found that a bacterial starter stimulates faster, more consistent fermentation than traditional methods and guarantees a better product.

Other researchers turned their attention to lower-salt franks and corned beef. They reported that just about all processed meats can be made with 20 to 25 percent less salt with no risk of spoilage. Proper refrigeration, it turns out, is more important than salt level in retarding the growth of microorganisms that cause spoilage.

PATHWAYS TO LEANER MEAT

Despite popular misconceptions, pigs don't "pig out." Scientifically balanced diets are important to producing ideal porkers.

ARS researchers have introduced foreign animals that have less fat. For example, they've been breeding a sheep from the Netherlands called Texel. It may prove to be an excellent source of lean meat, either inbred or crossed with domestic breeds.

FARM-GROWN CATFISH

Long regarded in the South as a down-home delicacy, catfish was hard to find in supermarkets elsewhere until recently. But now, thanks to aquaculture, pond-raised catfish is a popular item in the frozen food case. ARS has helped scale up fish farming by breeding fish for disease resistance, finding better feeds, and eliminating chemicals and pondwater contaminants that contribute to off-flavors.

OATRIM

Science supports grandmother's advice that oats are good for you—they can help lower cholesterol levels. Scientists speculate oats may accomplish this by slowing the rate at which the intestines absorb carbohydrates.

An ARS chemist has created a low-calorie, cholesterol-fighting fat substitute called Oatrim from soluble oat fiber. A study by ARS nutrition scientists showed that Oatrim reduces cholesterol and lowers blood glucose linked to diabetes. An unexpected payoff: most of the volunteers lost weight even though they increased their calorie intake.

Oatrim is a light, tasteless powder that can be incorporated into baked goods. It can also be used to prepare a frozen dessert that resembles soft ice cream. A 4-ounce serving of the dessert contains 135 calories, less than 1 gram of fat, and 4 milligrams of cholesterol. (Premium ice cream has 298 calories, 22 grams of fat, and 85 milligrams of cholesterol.)

In 5 short years, this excellent fat replacement technology has been transferred from lab to grocery store and now is listed on the label of hundreds of products as hydrolized oat bran.

SUGAR

You could easily fill a book with the details of ARS sugar research, and the plot would never be saccharine. U.S. sugarcane growers agree their success can be traced in large part to ARS sugarcane research and variety programs.

We've supplied those growers with 86 new varieties of cane—and it takes between 8 and 10 years to develop just one. But the payoff's been worthwhile—high-yielding sugarcanes, most armed with resistance to diseases like sugarcane mosaic virus, eye spot, smut, rust, ratoon stunting, leaf scald, and the like. And some varieties have been bred to fend off insects.

Over the years, we've helped the sugarcane processing industry with many needs, including better cane yields per acre and juice with a high sugar content. We also proved to growers that fresh cane, delivered to mills immediately after harvest, yields more recoverable sugar than cane left lying in fields after cutting.

We also developed two processes for making specialized sugars for the candy industry. One, turbinado sugar, was made directly from cane juice during harvest without refinement. The other produced sugar whiter and purer than turbinado. It proved perfect for pale-colored candies like mints.

And we're not just raising cane. We've improved the process of making sugar from beets, cutting sugar losses from 3 pounds per ton to 0.6 pounds.

HONEY

After analyzing hundreds of samples, ARS researchers wrote the definitive report on the composition and properties of honeys. These findings made it possible to detect the addition of other substances to honey. A side benefit was discovery of a new sugar in honey, which was named erlose, after ARS's Eastern Regional Research Laboratory.

MAPLE SYRUP

American Indians taught the early settlers how to make maple syrup, and for many years, that was that. But beginning in 1948, ARS research modernized every aspect of the process:

- Instead of collecting sap in buckets, lines of plastic tubing were installed, leading to central collection points.
- Germicidal pellets controlled growth of microbes at the taphole, extending the sapflow season and producing larger yields.
- Precision instruments controlled evaporation more carefully. Sanitation in evaporator houses was improved.
- Processing was improved to produce a syrup free of caramel and other off-flavors.

DO YOU KNOW A SOYBEAN WHEN YOU EAT IT • WEAR IT • READ IT?

Soybeans have found their way into an eye-opening array of foods. Starting with the basics, there's soy milk, used in infant formulas. And the familiar Oriental staple tofu, soybean curd, is made by coagulating soy milk. But also consider soy yogurt, soyburgers, soy loaf, and soy sausage. Soy oil is the most widely used edible oil in the United States; you'll find it in mayonnaise, salad dressing, process cheese products, dessert frostings, and much more. Soy components such as protein and oil are ingredients in dozens of everyday foods—from the granola bar you eat for breakfast and the potato chips at lunch, to a late-night sandwich. And, attention chocoholics! You'll be hard put to find a chocolate treat that lacks soy lecithin.

Most soybean varieties have the Agricultural Research Service in their pedigree. Between 1980 and 1994 alone, agency scientists released 66 varieties and 280 breeding lines.

Thanks to ARS research, soybeans have been incorporated into a host of nonfood products. These range from your morning newspaper printed with soy oil-based ink to lipstick, plastics, flooring, paints, and stain-removing cleaners.

What more can we make of the soybeans? At one ARS lab, we're cloning soy's genes for proteins, with an eye to improving its nutritional quality. At another, we're trying to learn how stress factors such as drought and heat affect the plant's ability to flower. (Fewer flowers mean fewer beans, of course.) And we're breeding specialized soybeans galore to tailor soy-based products for every niche, from the supermarket to the export market!

TRACKING OUR NUTRITION

How much vitamin A should a 15-year-old boy get? Does a 52-year-old man need the same amount of protein as a 60-year-old woman? A 25-year-old woman? Will fish-oil supplements help lower cholesterol levels? These are some of the questions that ARS nutrition scientists must address. They do the background research for those familiar RDA's (recommended dietary allowances) and the Food Guide Pyramid that you see on the sides of cereal boxes. Other nutrition researchers serve as nutrition accountants, keeping track of constituents in the foods we eat.

COTTON: BATTING A THOUSAND

Cotton—shoppers find it in the socks and underwear section, not to mention where cloth diapers and first-aid products are sold. And why not? It's often the fabric of choice, and it's being improved all the time.

Cotton has had its problems, though—including safety problems like flammability. It was ARS scientists who conducted the initial work on flame-retardant finishes. In 1953, a chemist came up with THPC, a compound that prevented cotton fabrics from flaring up when held in a flame—instead they formed a tough black char. Unlike many other chemicals tested for flame retardancy, THPC survived laundering and drycleaning. It was first used in military combat clothing, firemen's uniforms, and hospital linens. But in a short time, flame-resistant finishes, which underwent many improvements, were applied to children's nightwear and many products. Still used today in an improved form, THPC has proved safe, effective, and nontoxic.

Does the thought of socks and underwear conjure up concerns about bacteria? Yes, microbes can reside and multiply in textile fabrics. But no matter—ARS researchers have developed treatments for cotton textiles with compounds containing peroxides. They resist bacteria and, as a bonus, resist fungi that cause athlete's foot.

When medics during World War II pleaded for self-clinging elastic bandages, stretch cottons were born. After the war, consumers asked us to make stretch cotton available in diapers, socks, and underwear. Within a matter of years, ARS chemists had invented three different ways to put more stretch into cotton.

After that, ARS helped unchain Americans from the ironing board. First our scientists brought forth wash-and-wear cotton shirts. Then we improved the process by which durable-press cotton fabric finish was created to pose no health risk to textile workers—our new way to cross-link cotton fibers used citric acid to do the trick. The improved process, which has been patented, keeps cotton fabrics wrinkle-free for more than 100 washings.

Today, everyone adores those zany designs that transfer onto cotton tee-shirts. But that iron-on heat transfer process, performed right before your eyes at the beach or boardwalk, wouldn't work on cotton—the transfer's disperse dye, which vaporizes when heated, has an affinity for polyester alone. Researchers have figured out a way to modify the cotton—so now your favorite cartoons and silly slogans "take" with ease.

BIODEGRADABLE CUTLERY

Petroleum-based plastics now take up about 25 percent of the volume of landfills. But knives, forks, and spoons made from a starch-polyester material won't contribute to the problem, thanks to ARS innovation. Various biodegradable starch-polyester compositions can be used for other one-time-use items such as plastic bags and wraps that are now made from petroleum.

INSECT REPELLANT

If we decide to donate blood, most of us would like to control when we donate it—and to whom. So mosquitoes are an outdoor nuisance to be avoided, as are biting flies, ticks, and chiggers. We ward all of them off with deet, a strong repellant that ARS discovered 40 years ago.

LET NO ROACH ENCROACH

No more jitters about crawly critters—our new roach bait belongs to a family of insecticides called fluorosulfonates. Discovered and patented by ARS scientists, these compounds work to control cockroaches, ants, and termites—insects that live in groups or colonies. The chemicals work especially well because insects carry the insecticide back to their nests to share with cronies.

STARCH THAT SLURPS

Starch is the main constituent of grain flours, and the most plentiful starch is cornstarch. Although most of the products from corn milling go into food and feed, 4.5 billion pounds of starch are annually produced, largely for nonfood purposes. Of this amount, 3.5 billion pounds are used in the paperboard, paper, and related industries, where starch serves both as an adhesive and a coating.

And new uses for cornstarch continue to surprise us. For example, when ARS scientists married starch to a synthetic chemical, they managed to create a product so thirsty, it could absorb hundreds of times its own weight in water. Someone called it SuperSlurper, and the name stuck.

After patents were secured in 1976, SuperSlurper started popping up all over the marketplace. The absorbent compound, which can slurp up to 2,000 times its weight in water, is used as an electrical conductor in batteries. You can find it in fuel filters, baby powders, and wound dressings. Compounds very much like it are now used in disposable diapers and sanitary napkins.

A CHANGE IN THE LEATHER

Leather-making is an ancient craft, but it's met up with some state-of-the-art technology. Electron beam radiation, we've found, can replace the salt solutions now used to kill bacterial growth—much to the benefit of the environment. Not only is brine curing corrosive to equipment; it contributes to water pollution.

We also found a way to reduce the number of poor-quality hides that make their way into leather processing. Laser light-scattering photometry can be used to evaluate hides according to the orientation of their fibers.

High-tech detective work has tracked down a cause of shoemaking woes. One type of leather, which broke under the stress of manufacture, was found to have a genetic defect that's specific to certain Hereford cattle.

It was ARS researchers who identified cockle, a seasonal flaw of sheepskin, as the work of a parasitic insect called keds. Once they realized that keds not only lowers the value of the skin but also causes sheep to grow more slowly, sheep farmers began treating their herds to control infestations.

PAPER THAT'S TREE-FREE

A fast-growing plant called kenaf promises to be an alternative to wood pulp for papermaking. Research dates back to 1956, when a team of ARS scientists singled out kenaf as a potential papermaking candidate. Today, through cooperative agreements with private firms, kenaf is poised to make the leap from the laboratory to full-scale production.

POINSETTIA, A SEASONAL FAVORITE

Not only is poinsettia the most popular Christmas plant, it is the number-one flowering potted plant in the United States, even though its traditional sales period is just 6 weeks.

That was not the case back in 1976, when ARS first began its program to improve the flower's dependability. This meant discovering the exact conditions of light and temperature the plant requires. They also performed breeding experiments that defined how color develops, and they devised precision growing methods that enabled massive cultivation.

Last year, the wholesale value of the poinsettia crop reached nearly $170 million—a jump of more than 400 percent from 1976.

AN AZTEC LEGACY

The poinsettia, a contemporary symbol of Christmas, was introduced to the United States and named after Joel Robert Poinsett in 1825.

Poinsett was serving as the first U.S. ambassador to Mexico when he saw the plant growing on the hillsides of southern Mexico, where the plant is native.

The Aztec Indians prized poinsettias and considered them a symbol of purity because of their brilliant red color.

They made a reddish-purple dye from the colored "flowers," which are actually modified leaves called bracts. They also made a medicine against fevers from the latex sap of the plant.

NEW FLOWER POWER!

Even convenience stores are selling flowers these days! The floral, nursery, and landscaping industry is one of the fastest growing sectors in agriculture.

Always on the lookout for promising additions, ARS plant geneticists recently screened more than 60 plants as possible candidates for floriculture. Here are three of the top contenders.

AGRICULTURE'S GREAT GIFT TO MODERN MEDICINE...

THE RESCUE OF PENICILLIN

In 1928, Alexander Fleming, a Scottish bacteriologist, discovered a mold with bacteria-killing powers so incredible it was effective even when diluted 800 times. The mold, which appeared to be relatively nontoxic, promised to have therapeutic value. If only it could be produced in quantity!

Efforts to produce large amounts of the elusive mold failed and failed again, and a worldwide disappointment set in. For the next 10 years, people continued to suffer and die from common infections while the promise of penicillin languished.

Then, in July of 1941, two British scientists, Howard Florey and Norman Heatley, visited the United States from war-beleaguered England. With them, they brought the mold, which had been converted into a stable brown powder.

Arriving in the United States, they were directed to USDA's Northern Laboratory, now a component of today's Agricultural Research Service, in Peoria, Illinois.

The scientists in Peoria immediately rolled up their sleeves and started their cultures of *penicillium*. By November 26, 1941 (just days before Pearl Harbor), Andrew J. Moyer, the lab's expert on the nutrition of molds, had succeeded, with the assistance of Dr. Heatley, in increasing the previous yields of penicillin 10 times.

The secret was corn steep liquor, familiar to agricultural researchers as a byproduct of the wet corn-milling process but obscure to medical researchers of the day. By including this nutrient-rich liquor in the culture medium, Dr. Moyer found a better growth medium than anything tried in England.

Dissatisfied still, he added milk sugar to the medium, and again the *Penicillium* mold doubled. Moyer also figured out how to use deep vats to grow the cultures.

So encouraging were the results that four U.S. drug companies agreed to attempt large-scale production of penicillin. Nevertheless, by March 1942, they'd only produced enough of the drug to treat a single case.

Then the Peoria researchers made yet another breakthrough. Searching for a superior strain of *Penicillium,* they found it on a moldy cantaloupe in a Peoria garbage can. When the new strain was made available to drug companies, production skyrocketed.

Thanks to the combined efforts of many people, penicillin was available in quantity to treat Allied soldiers wounded on D-Day. And ever after.

In 1987, Moyer was posthumously named to the National Inventors Hall of Fame in Arlington, Virginia. There he joined such luminaries as Thomas Edison, Luther Burbank, and the Wright brothers. Dr. Andrew Jackson Moyer was the first Government researcher ever to be inducted.

THE AGRICULTURAL RESEARCH SERVICE

The application of research to science is a good investment, one that more than pays for itself. While farmers, ranchers, and food processing companies are generally the first users of new knowledge and technologies, it's not difficult to locate many of these improvements to our food supply on grocery store shelves and other retail outlets.

Year round, Americans can safely stake their well-being on reliable and affordable supplies of fresh and processed food—the greatest agricultural bounty in the world. The cost? In terms of disposable income, we Americans pay far less for food than citizens of other countries.

The items illustrated in this publication have been chosen to depict the scope and variety of agricultural research—think of them as snapshots representing a far vaster field of achievements. Remember too that ARS research does not take place in an institutional vacuum; a number of these technologies and products could not have been developed without the tireless efforts of a host of cooperating universities and industries throughout the country.

In addition to the product-oriented research outlined here, much of ARS research lays the foundation for future development. A growing proportion falls under the broad heading of biotechnology. Many biotech projects deal with difficult, long-term problems. In some cases, the probability of success may not even be known when the work is begun.

The Agricultural Research Service spans the country with facilities that are strategically located in the major farm and rangeland ecosystems throughout the United States. This enables ARS to bring research expertise to bear on agricultural production and utilization problems of national scope from many different geographic vantages.

Science in Your Shopping Cart was written, edited, photographed, designed, and produced by the ARS Information Staff.

Next time you make your way through the supermarket aisles, give some thought to all the scientific accomplishment your shopping cart contains. After all, the ultimate beneficiaries of agricultural research are America's consumers!